

# Causes of Extreme Dry Conditions over Western U.S. during Early 2013

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NASA/GMAO<sup>1</sup>; SSAI<sup>2</sup>

October 21, 2013

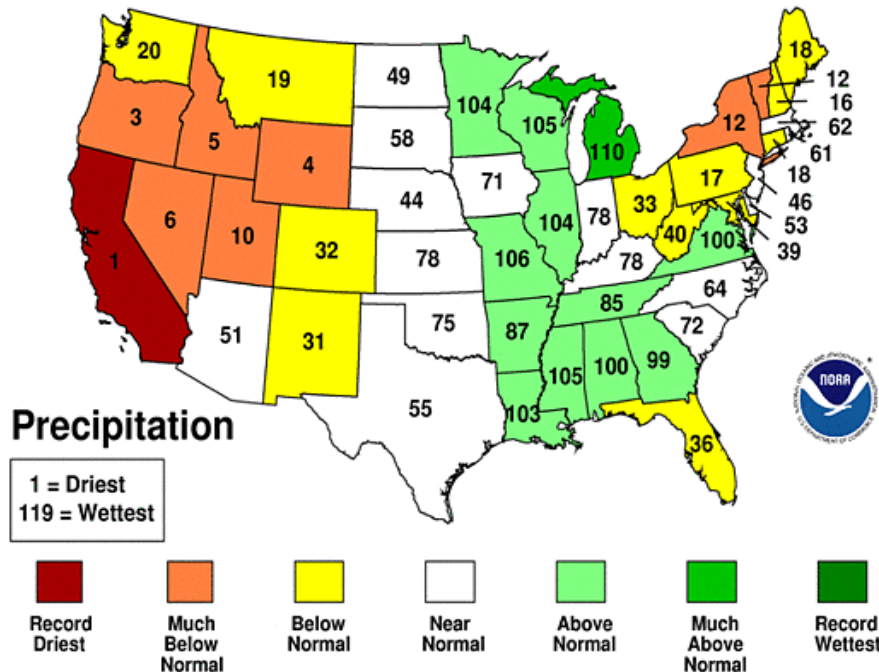


# Extreme Dry Anomalies over Western Coastal U.S.

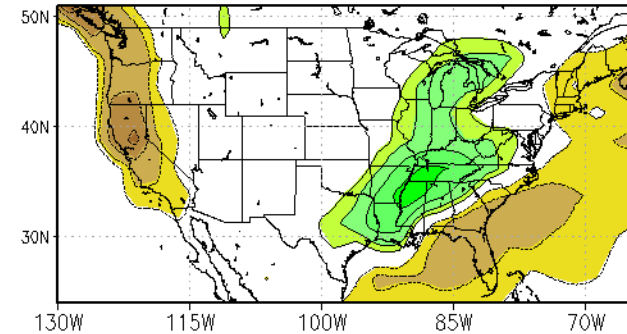
NOAA PREC (wrt 1980-2010)

NCDC (wrt 1895-present)

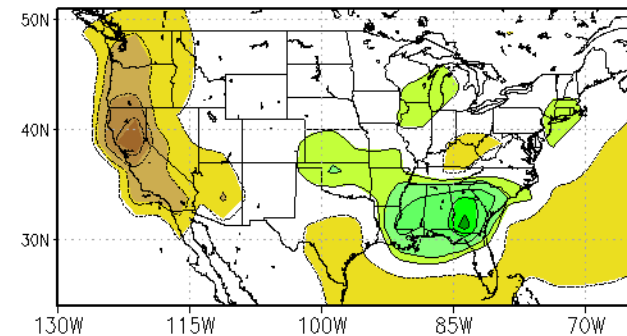
## January–March 2013 Statewide Ranks National Climatic Data Center/NESDIS/NOAA



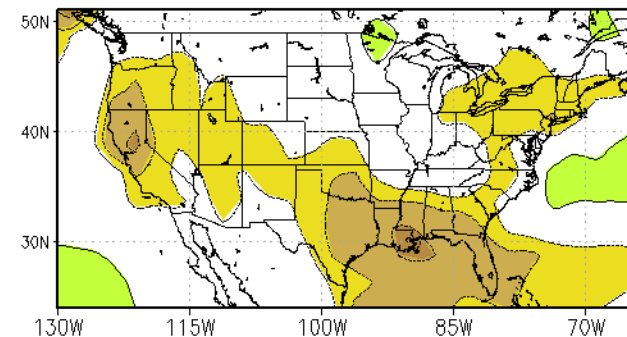
Jan2013



Feb2013



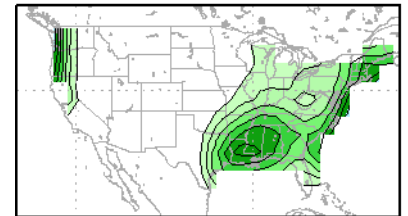
Mar2013



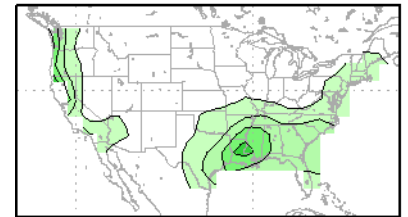
# Precip over Western U.S.

- Mainly over Pacific northwest, and comes from extratropical cyclones from the north Pacific under the strong wintertime jet stream
- Precip over California: southwesterlies from north of Hawaii
- Influencing factors
  - ENSO
  - MJO
  - Atmospheric internal variability
  - Variations on decadal and longer time scales
    - PDO
    - Long-term trend

GPCP DJF  
Climatology



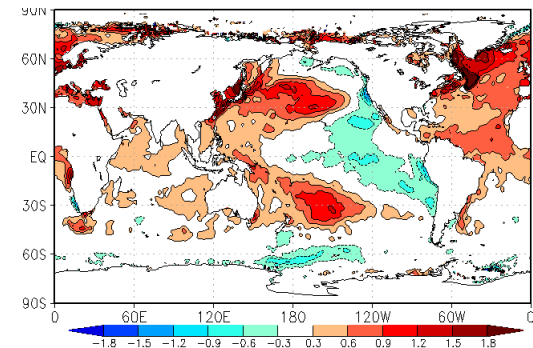
Standard deviation



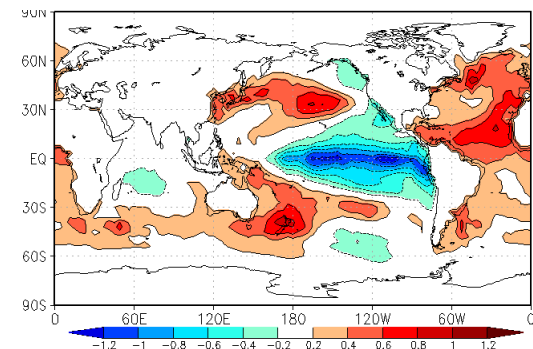
# Data

- Obs precip
  - NOAA PREC (Jan1948-Apr2013)
  - GPCP (Jan1979-Dec2011)
- MERRA reanalysis
  - Jan1979-present
- NASA GEOS-5 AGCM Simulations
  - 1 degree
  - AMIP
    - 12 members; Jan1871-present
  - Idealized AGCM runs
    - Clim SST (1901-2004)
    - Anom SST: ColdPac+WarmAtl+WarmTrend
    - 50 years long, with a repeating seasonal cycle
- Anomalies: wrt 1980-2010 mean

Linear Trend of Annual HadISST  
1980-2011



ColdPac + WarmAtl + WarmTrend



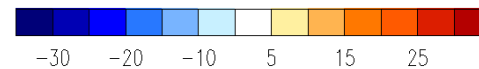
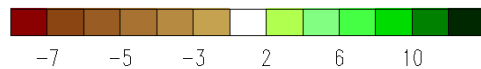
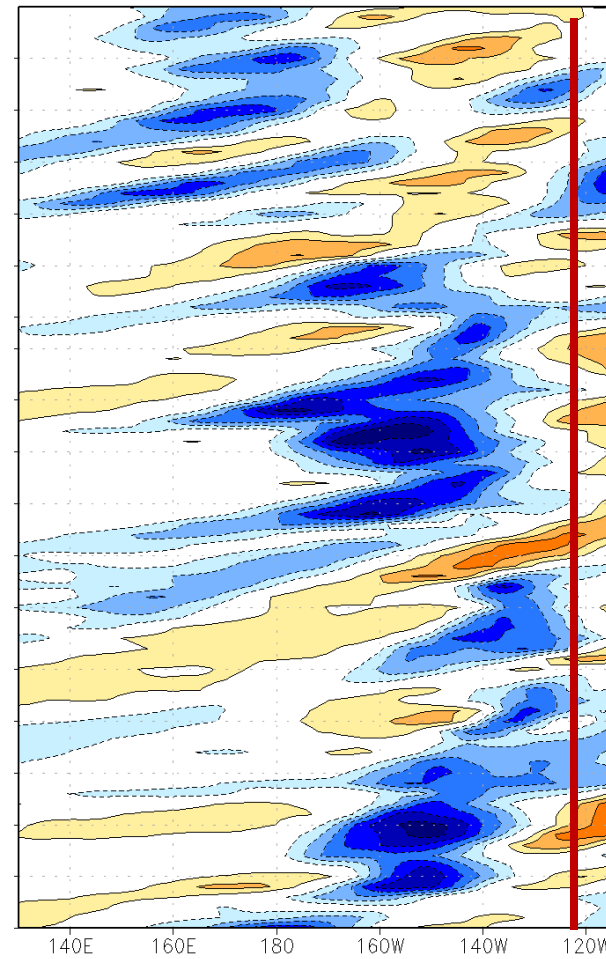
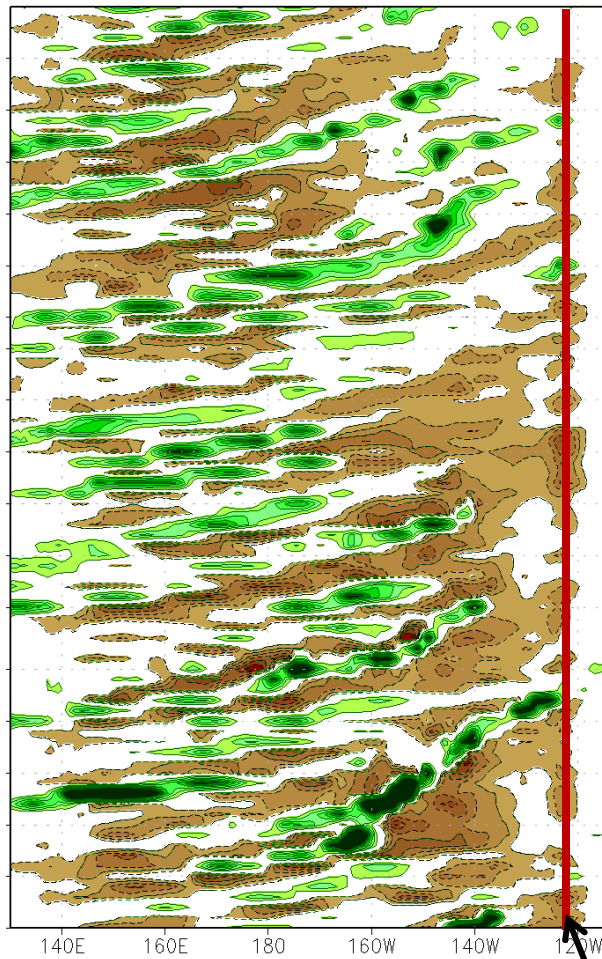
# MERRA: Daily Evolution

31Mar  
2013

Precip (32N-45N)

U250 (20N-40N)

1Jan  
2013

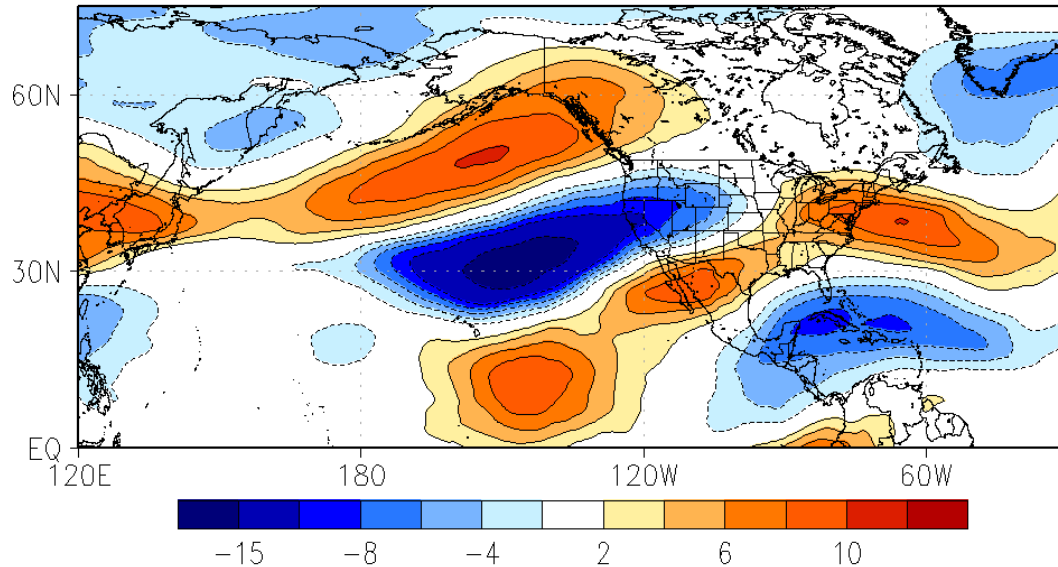


US west  
coastline

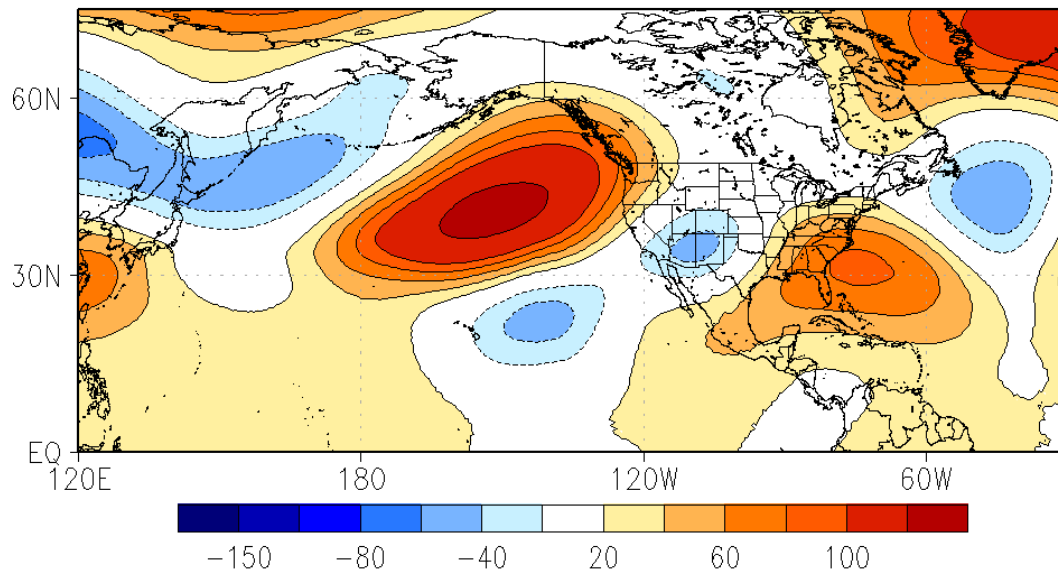
Considerably less north Pacific storms reached U.S. west coast  
Considerably weaker zonal wind over NE Pacific

# Atmospheric Circulation: 250mb; JF2013

## U250



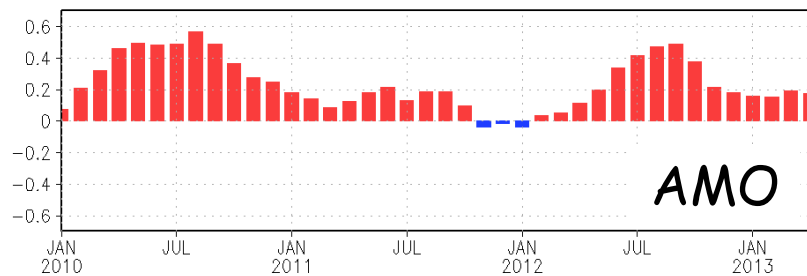
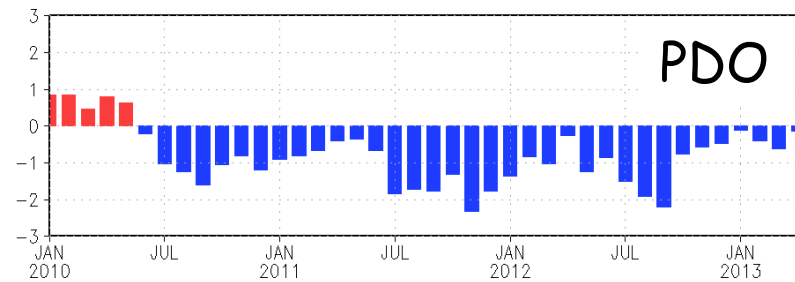
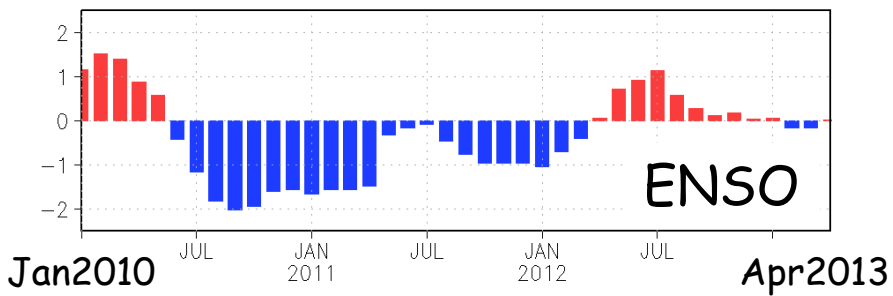
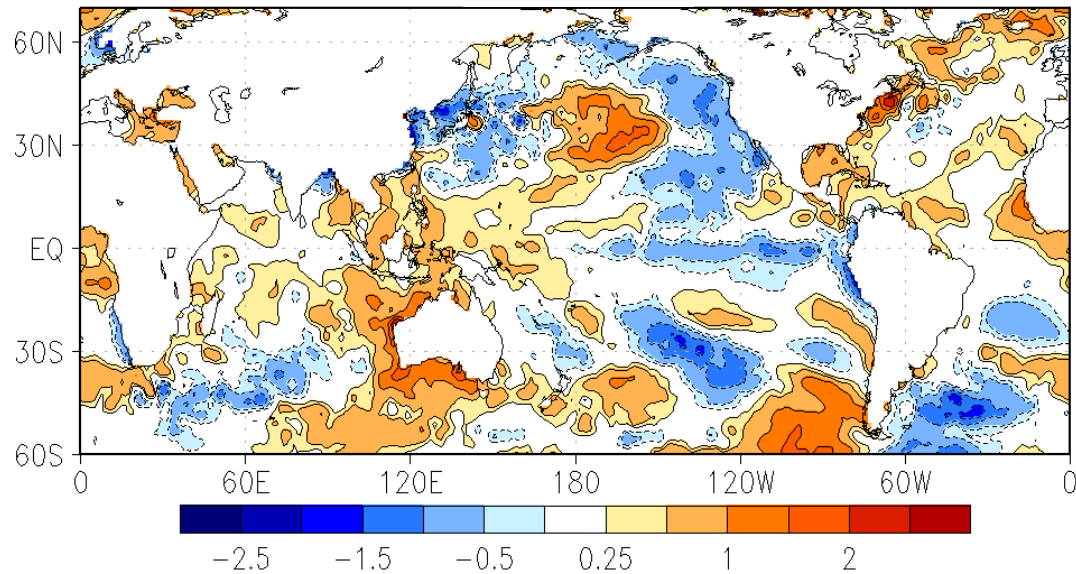
## Z250



Similar to other dry winters for California, persistent ridge (40°N) and weaker zonal wind (30°N) over NE Pacific prevented north Pacific storms from reaching U.S. west coast.

# SSTA

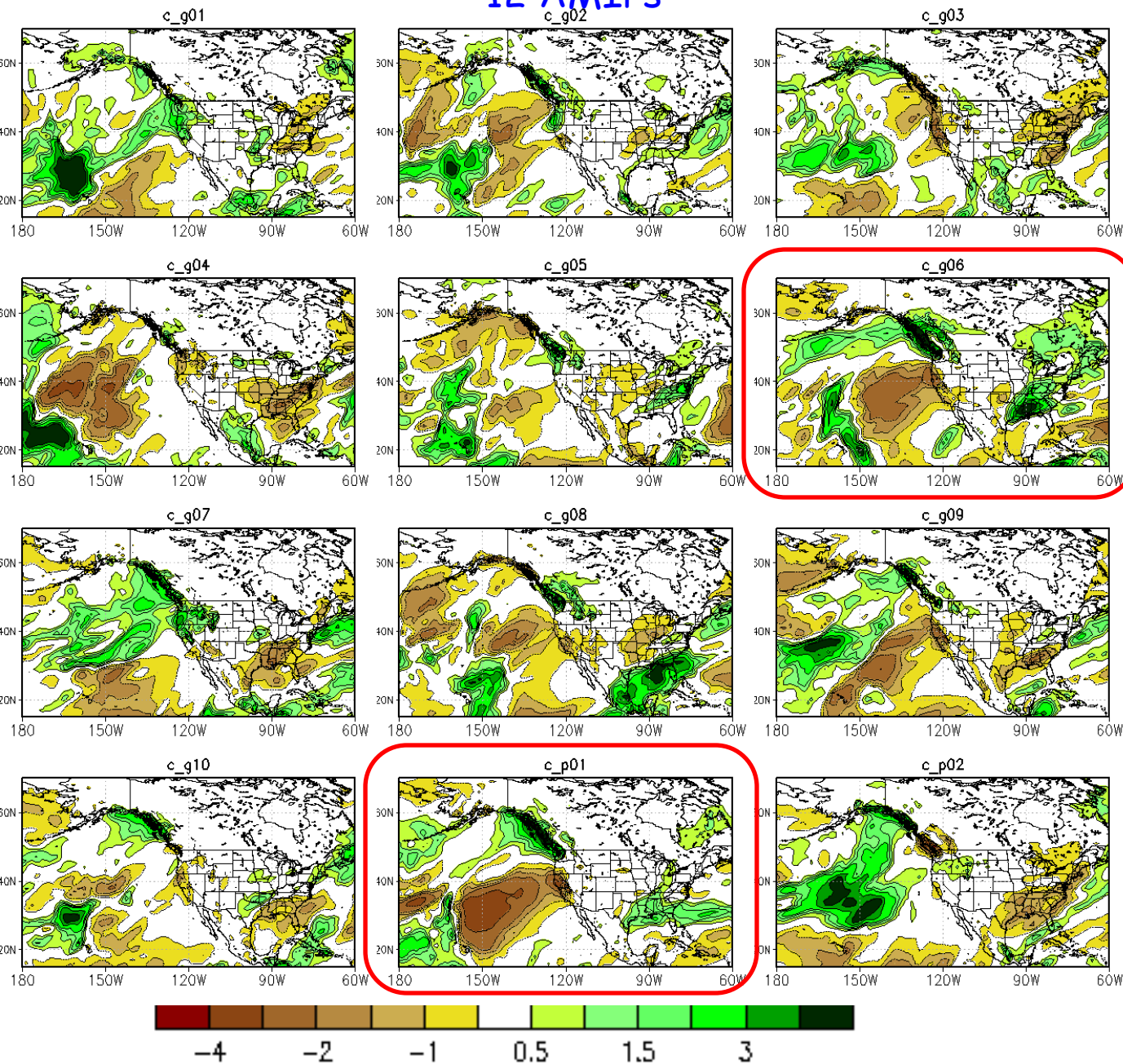
JF2013



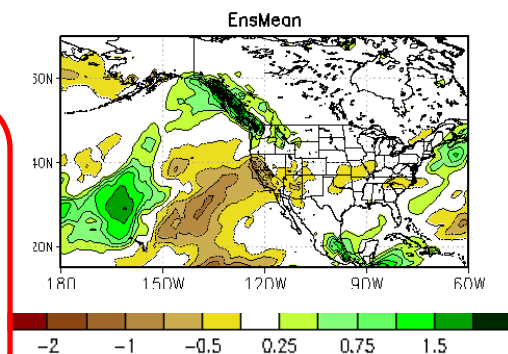
Cold ENSO like pattern,  
but with weak SST indices

# Precip: GEOS5 AMIP vs. MERRA

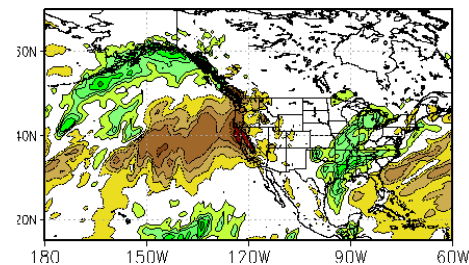
12 AMIPs



AMIP EnsMean



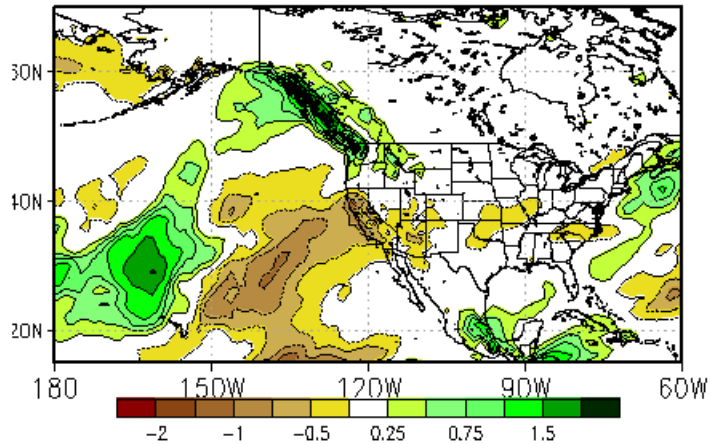
MERRA  
MERRA



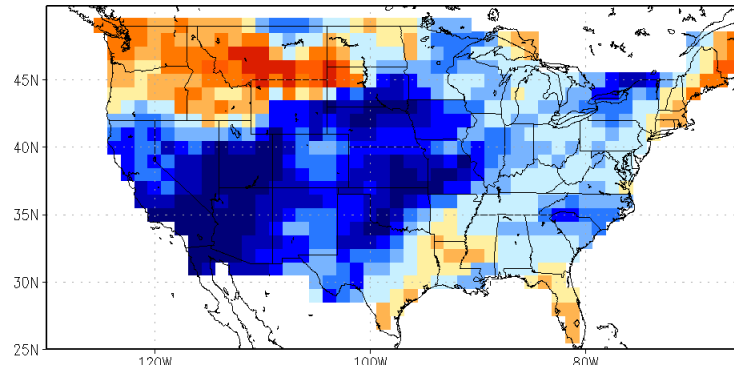
Good agreement

# Precip: AMIP EnsMean vs. MERRA

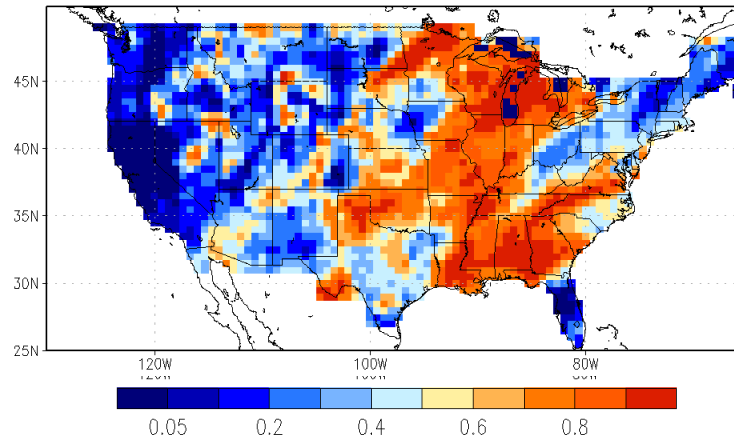
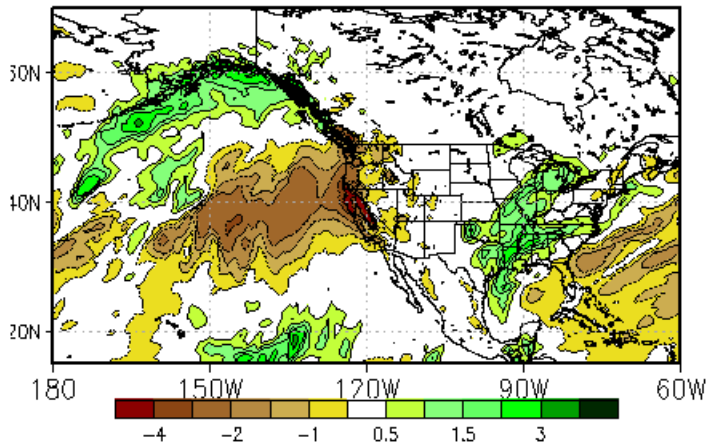
Precip



Precip Percentile



AMIP  
EnsMean



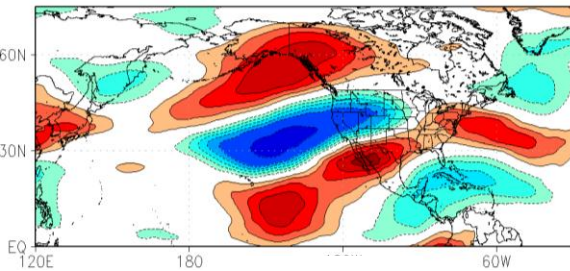
MERRA

SSTA in Pacific contributed to the dry anomalies over SW US

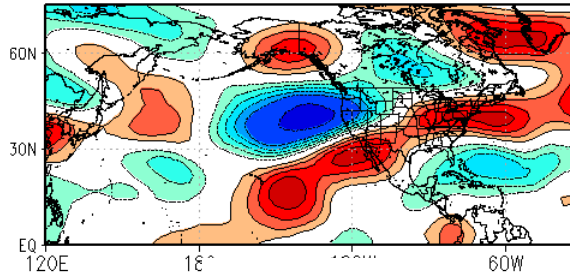
# Stationary Wave Modeling Diagnosis

Eddy u250; JF2013; MERRA

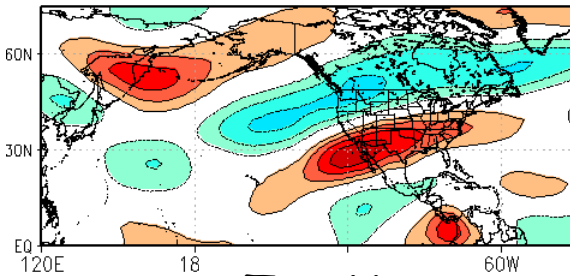
MERRA



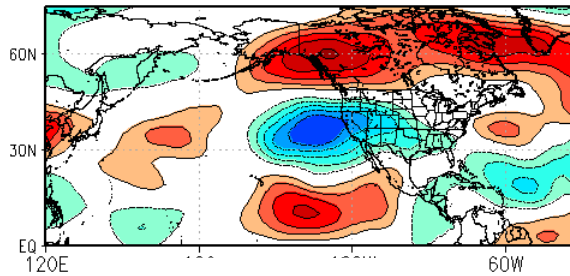
Heat+Tran



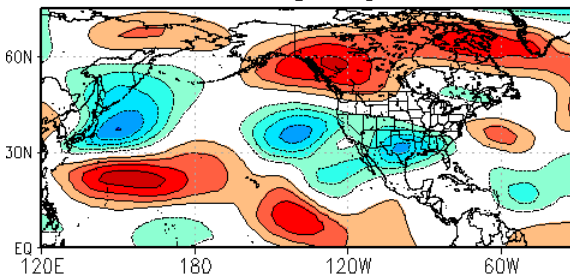
Heat



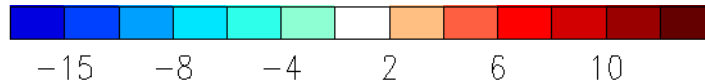
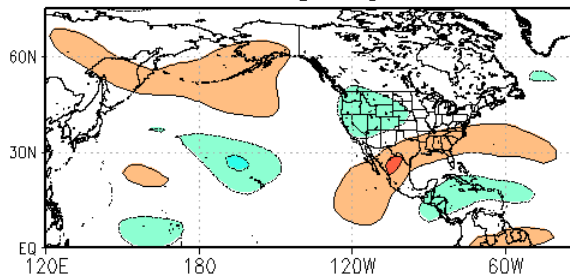
Tran



TranVor



TranTemp

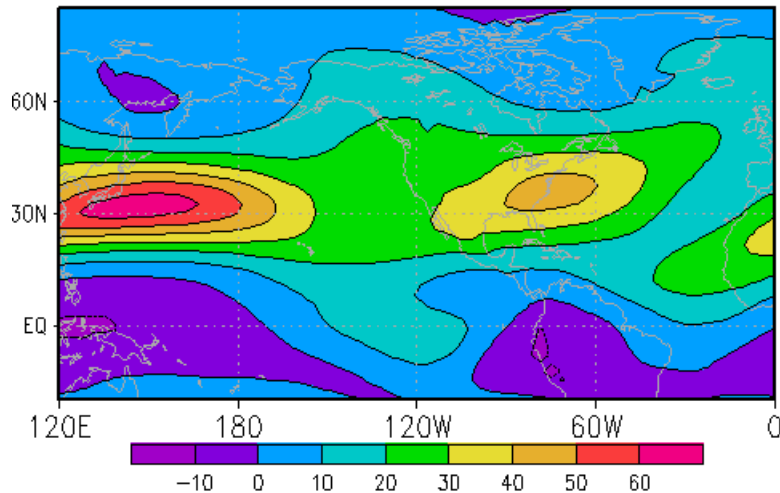


The weakened zonal wind over NE Pacific was primarily maintained by changes in transient vorticity flux convergences (TranVor), and secondly by heating (Heat) anomalies.

# Climate Variations on Decadal and Longer Time Scale Through Changing Basic State

Clim vs Anom (ColdPac+WarmAtl+WarmTrend)

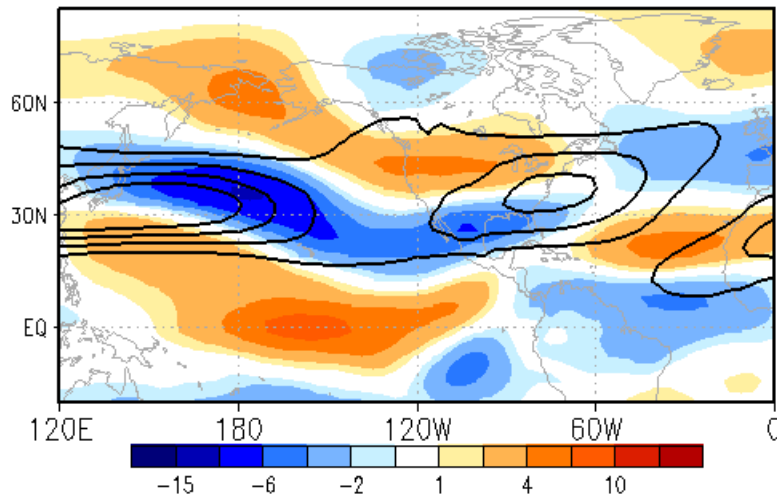
PnAn u DJF



PcAwLTw dominated by Cold Pacific

The effect of PcAwLTw through changing mean basic state is investigated by examining the changes in optimal forcing pattern for the zonal wind over NE Pacific, using a stationary wave model

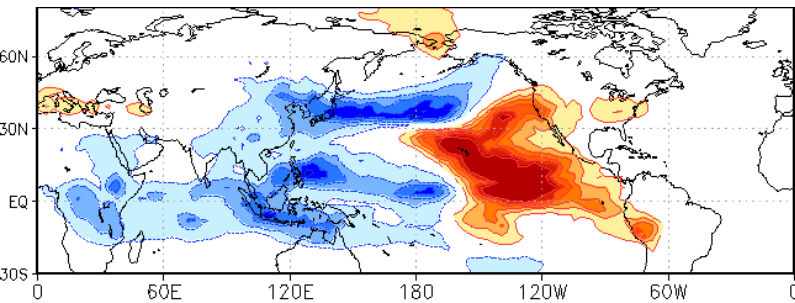
ColdPac+WarmAtl+WarmTrend



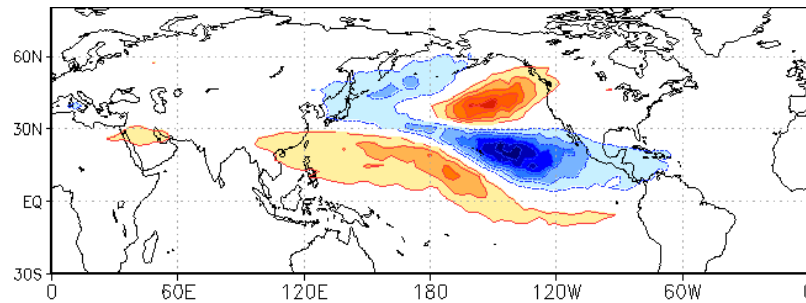
# Climate Variations on Decadal and Longer Time Scale

## Optimal Forcing Pattern for U250 over NE Pacific

Heating

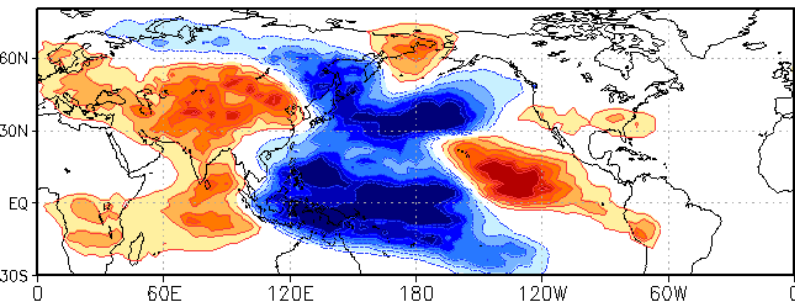


TranVor

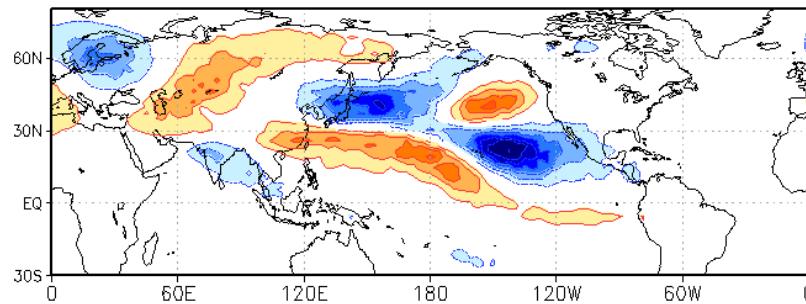


Clim

Heat PcAwLTw



TranV PcAwLTw



Anom  
(PcAwLTw)



The changes to the basic state due to PcAwLTw allows forcing over Pacific to exert stronger effects over NE Pacific and western U.S.

# Summary

- Immediate Cause
  - Less North Pacific storms reached west coast of U.S., due to considerably weaker zonal wind over NE Pacific
- Underlying Causes
  - SSTA: cold ENSO-like SSTA contributed to dry anomalies over SW U.S.
  - Atmospheric internal variability: dominant role of transient vorticity flux convergences for the weakened zonal wind over NE Pacific
  - Climate variations on decadal and longer time scales, especially the ongoing negative PDO: the changes to the basic state allows forcing over Pacific to exert stronger effects over NE Pacific and western U.S.